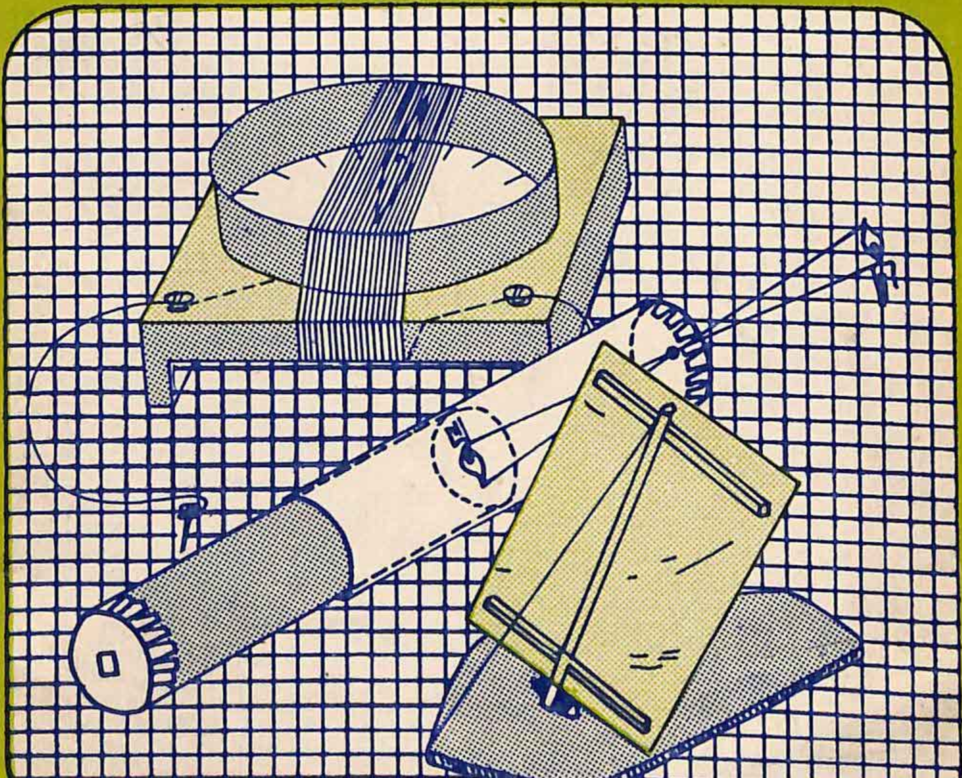
FUN WITH PHYSICS

Dilip M Salwi



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Dilip M Salwi

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To
Shri M.R. Raman,
whose words have always been a source of inspiration.

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Finding the Diameter of the Moon

When you look towards the Sun or the Moon, one exciting question always arises in your mind: "How big are the Sun and the Moon?" If you ask others, they may not be able to satisfy you. But how exciting it will be to do a simple experiment and get the diameters yourself! Let us first find the diameter of the Moon.

Select a night shortly before full Moon for your observations. Choose a window through which you have a good view of the Moon. Take two gummed strips of paper, paste them horizontally on the windowpane about 2 cm

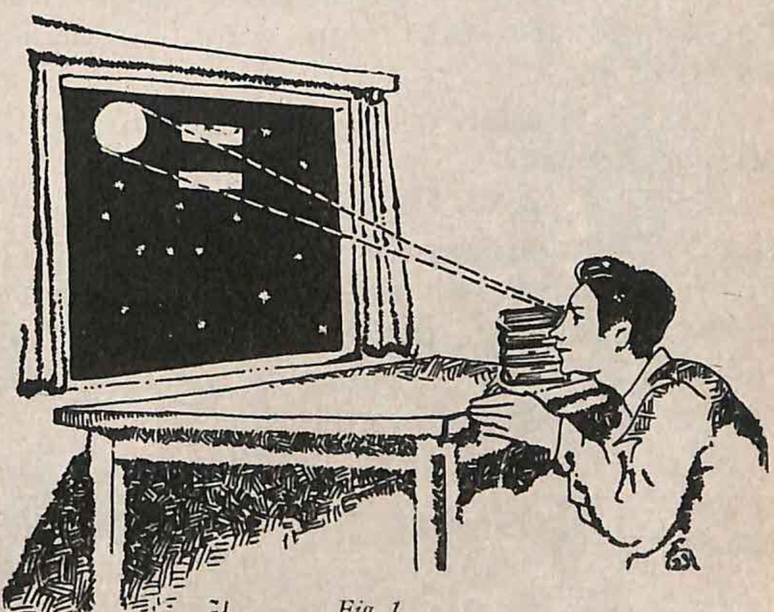

Fig. 1

apart. Provide yourself with a table from which you can comfortably see the Moon. Take a pile of books at hand for marking your position.

When the Moon is visible between the strips, adjust yourself, by moving forward or backward so that the Moon's disc just touches the strips—not more, not less. This observation should be carefully taken. Having taken the exact position, bring the book on top of the pile up to your face, so that its corner just marks the point, where your eye was.

Measure the distance between the strips and the corner of this book, either by using a metre tape or thread. Repeat this measure three times and take the mean.

Now we know that the distance between the Earth and the Moon in round figures is 38,000 km.

In two similar triangles OAB and OCD shown in Fig. 2

$$CD/AB=OD/OB$$

that is, The diameter of the Moon in km/The distance between the strips in cm=The distance between the Earth and the Moon in km/The distance between the strips and corner of the book in cm.

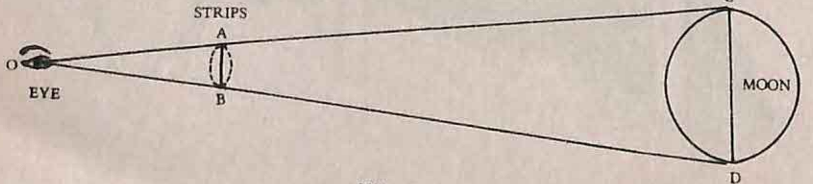

Fig. 2

Therefore, by substituting three known values, we get the diameter of the Moon in km. This crude experimental value will differ from the most exact astronomical figure by only thirty kilometres.

Finding the Diameter of the Sun

Now we will do another simple experiment to find the diameter of the Sun. Here we cannot use the same method, as we cannot look directly at the Sun.

Select a window through which you have a full view of the Sun at any time, preferably between 9 a.m. and 3 p.m. Take a black chart paper having a pin hole and fix it over the

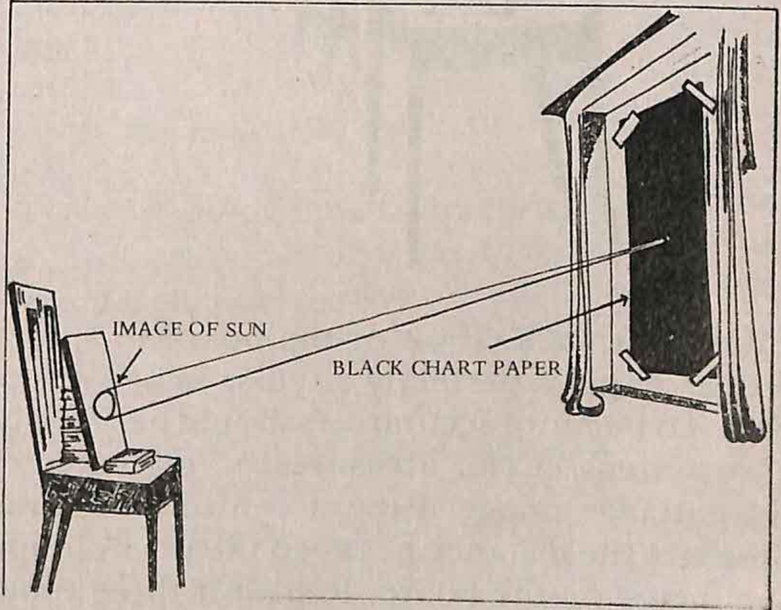

Fig. 3

windowpane using gummed strips. Through the pin hole, the Sun will form its inverted image—an oval-shaped spot. Find out this spot which may be on the floor or on the opposite wall of the room. Having found it, place a chair over that place, so that the image falls on it (see Fig. 3).

Now take a wooden board fixed with a sheet of paper. Make it stand on the chair in a slanting position, using books (see Fig. 4).

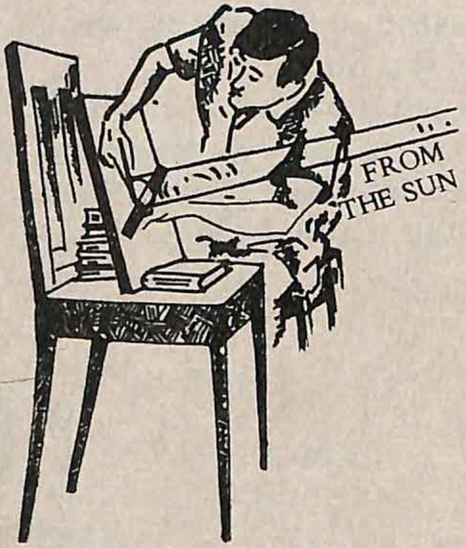

Fig. 4

Adjust the inclination of the board in such a way as to get a perfectly circular image of the Sun. To be more accurate, it should be a bright and perfect circle. Measure the diameter of the circular image using a centimetre scale. Measure the distance between the pin hole and the image on the board. Repeat it three times and take the mean. Also, you know that the distance between the Sun and the Earth, in round figures, is 149,000,000 km.

Again, taking the two similar triangles OAB and OCD as shown in Fig. 5,

$$CD/AB=OD/OB$$

i.e., The diameter of the Sun in km/The diameter of the circular image of the Sun in cm=The distance between the Earth and the Sun in km/The distance between the pin hole and the image on the board in cm.

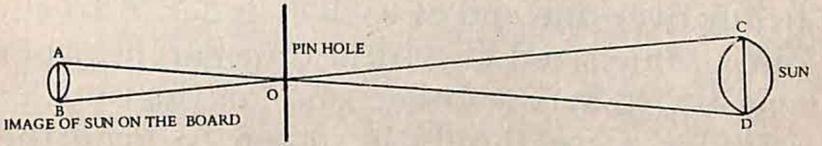

Fig. 5

Therefore, by substituting the three known values, we get the diameter of the Sun in km. Repeat the experiment with different diameters of the image. These you will get by moving the board towards or away from the pin hole.

So, by knowing the diameters of the Sun and the Moon, you can also get their volume and circumference using the formulas, which you will get from any higher arithmetic book.

A Pin-Hole Camera

Pin-hole camera is the device on whose working principle photographic camera is based. So by making it you can understand how a camera works.

Materials needed: Black chart paper, transparent tape, a ruler, pin and blade.

Method: Cut out two sheets of paper 23 cms by 33 cms. Roll them and make two cylinders with the help of gum and tape, one easily sliding into the other. Cut out two circular discs of paper, of bigger diameter than those of the cylinders as shown in Fig. 6. Apply gum to the other parts and with the help of tape fix them firmly over one end of each cylinder. Also cut out a same-sized disc from transparent paper and fix it at the other end of the smaller cylinder. Care should be taken to keep the paper perfectly clean. Keep them in the sun to dry.

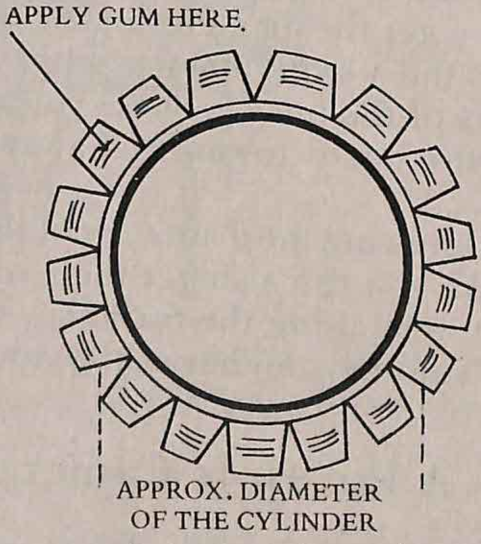

Fig. 6. How to cut circular discs and attach them to the cylinders.

Pierce a fine pin-hole at the centre of the discs of the bigger cylinder. With the help of the blade, cut out a small portion of the disc of the smaller cylinders as shown in Fig. 7. Care should be taken to see that light does not enter the box except from these two holes.

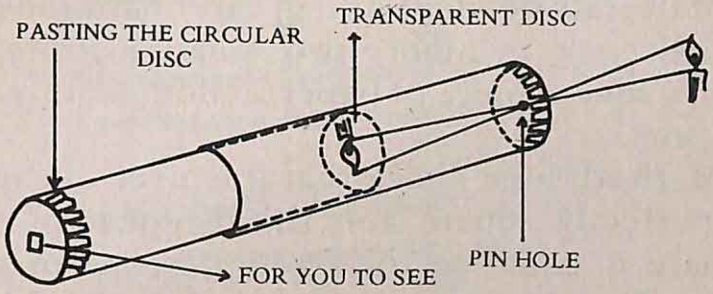

Fig. 7. The working of a simple pin-hole camera.

Your pin-hole camera is now ready for use. Face the pin-hole to the object you want to see and adjust the smaller cylinder so that you can see a clear inverted image of the object. In order to see the object, you have only to face the pin-hole to it and adjust or 'focus' the cylinder. The photographic camera has a similar adjustment.

Note: If you don't get black chart paper, colour that side of the sheet black which you are taking inside while making it into a cylinder.

A Periscope

On many occasions you might have longed to see what was happening behind a high wall which you could not climb over. A gadget called "Periscope", will enable you to see easily what is behind a high wall. In fact, when submarines are under water they use periscopes to see what is happening on the surface.

Materials needed: A long cardboard tube (a shuttlecock cylinder, two small mirrors, a saw, a square piece of paper, cellotape, thread, scissors.

Method: First check that the piece of paper is perfectly square and the diagonal of the square is equal to the circumference of the tube. The squarishness of the paper should be judged by checking whether all its sides are of the same length and all the angles between the sides are of 90 degrees. Taking a thread, measure the circumference of the tube and check whether it is equal to the diagonal of the square.

Place the squarish paper on a table and then keep one end of the tube over it as shown in Fig.8a. Roll the paper over the tube and fix the two corners of the squarish paper with cellotape (see Fig. 8b). Then take the saw and cut the tube along the edge of the squarish paper (Fig. 8c). When more than half of the tube is cut, leave the tube alone. Here onwards the tube should be cut straight down from a point right above where it was left off earlier (Fig. 8d). When a clean cut has been made, the section should be removed. Then the cross-section of the cut would look as shown in Fig. 8e.

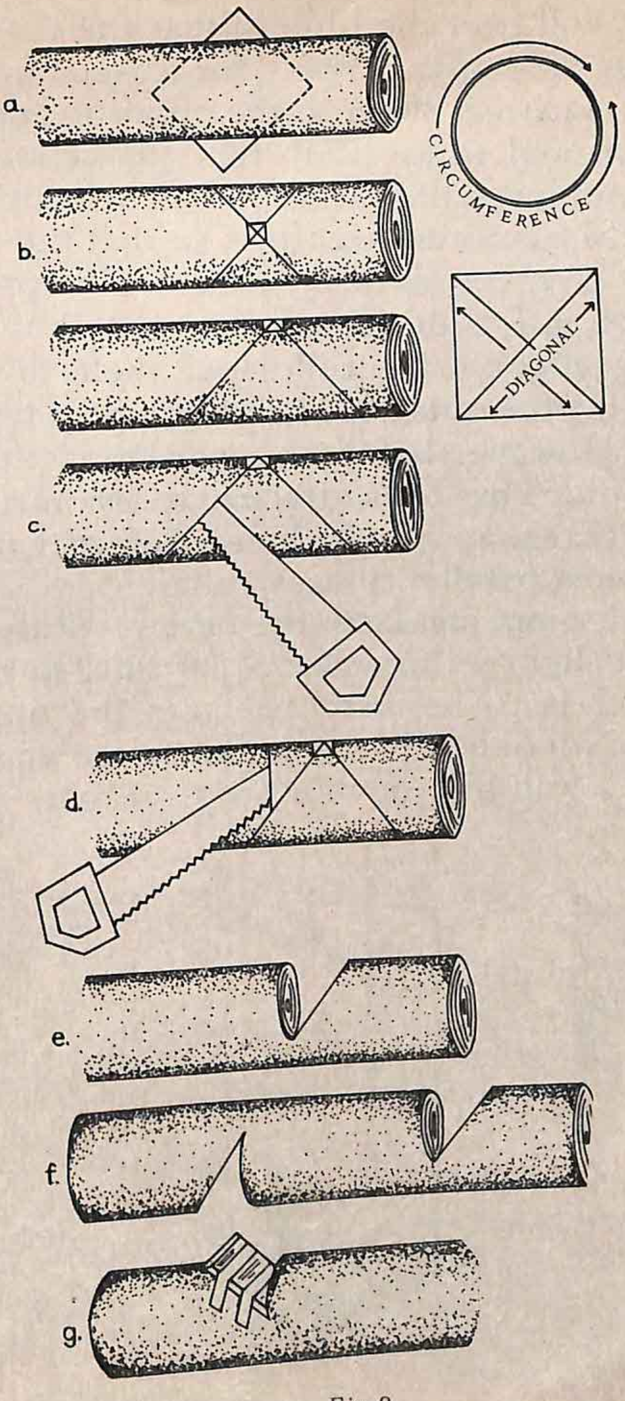

Fig. 8

Now, roll over the tube so that the exactly opposite side of it is ready for further work. Slid the squarish paper to the opposite end of the tube and rotate it so that the cellotape patch looks as it did earlier in Fig. 8b. Cut the tube now as was done earlier, so that the two cuts at the two ends of the tube finally appear as shown in Fig. 8f. Attach the mirrors at the slanting edges using cellotape, their silvery side facing the outside. The periscope is ready for use. However, before using, make sure that the cellotape has been attached to the mirrors firmly, that they are not loose, and that they are almost parallel to each other.

For viewing, just keep the tube vertical and move it slightly this side or that side, so that whatever is to be watched faces the upper mirror. Not only will one be able to see what is behind a wall but much more than that.

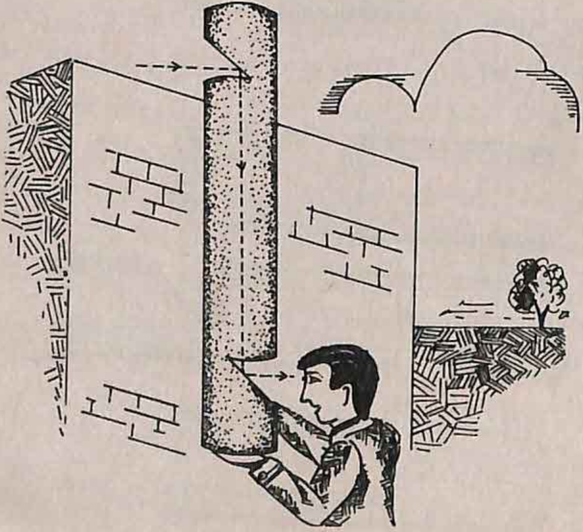

Fig. 9

A Candle-Powered Boat

How many of you have wished you had a boat of your own? Here is how to make a boat for yourself. You may wonder whether it is to be one which moves by petrol, steam or oars. My young friends, the one we are going to build is none of the above types. It moves simply using a lighted candle!

Materials needed: A piece of plywood 20 cm by 7.5 cm, light twigs at the most one-fifth of an inch thick, a sheet of paper, a piece of candle, cellotape, glue, thread, pin and a saw.

Method: Cut the plywood piece in the shape as shown in Fig. 10 using the saw. Make a circular groove in the plywood at a distance of 6.2 cm from the front. Cut off the twigs, one long and two others 7.5 cm each. Fix the two smaller pieces on the longer twig, one near each end (see Fig. 11). This can be done by cutting small grooves at the middle of the

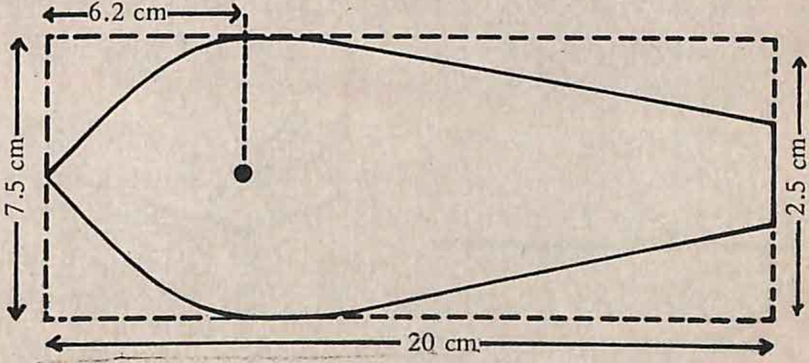

Fig. 10. How to cut the plywood piece.

smaller pieces and fixing them on the longer pieces with the help of cellotape and glue. Now cut the sheet of paper into a rectangular piece with its dimensions slightly larger than the rectangle formed by the small twigs. Paste the sheet over them by applying glue over the twigs. Keep the whole under the sun for drying. This is the 'sail' of your boat. Fix the sail over the groove in the plywood using pieces of wood, glue, cellotape and thread-pin arrangement, bearing in mind that the sail makes an angle of 50 degrees with the plane of the plywood (Fig. 11). Your boat is now ready to be launched.

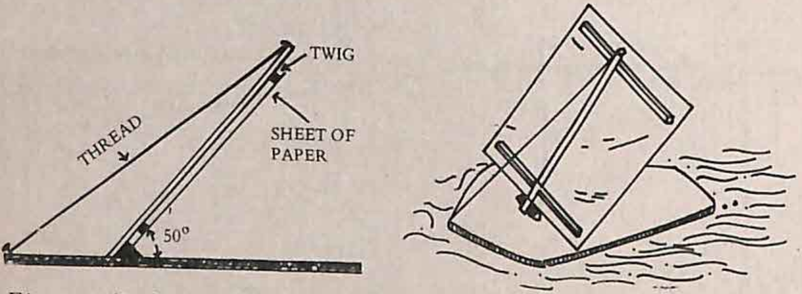

Fig. 11. (Left) How the paper sail is fixed. (Right) The completed boat.

Choose a room with the doors and windows closed to avoid wind disturbances. Place the boat in a tub full of calm water. Now you have to adjust the place of the candle on the boat so that the boat moves. While doing so, one should always take care to see that the candle is not so near the sail as to burn it.

If it is fixed at the right place, you will find the boat moving swiftly over the water with uniform speed, and if all this is conducted in the dark, it will look thrilling.

Note: As the boat moves when the hot air pushes the sails (air being heated by the candle), one should wait for some time for the boat to gain movement.

A Hot-Air Balloon

Gone are the days when man tried to fly by means of hot-air balloons. Even airships, which were modified version of the balloons, are not seen today. The adventure that men experienced when they were lifted above the surface of the earth by means of balloons is over. But the same thrill can be experienced in a small way if a hot-air balloon is made at home. Here is how to make a hot-air balloon. See it rise up in the air!

Materials needed: Five sheets of tissue paper 50 cm × 75 cm, gum, paperclips, blade, cotton, cardboard, spirit, ruler, scissors, thread and old newspaper.

Method: Take four sheets of the tissue paper and fold them all together, once lengthwise and twice breadthwise, as shown in Fig. 12a. Cut diagonally across two rectangles at the upper two ends of the sheets as shown. Now take the fifth sheet of paper and cut its longer side so that it becomes a square measuring 50 cm × 50 cm. Place the square sheet on an

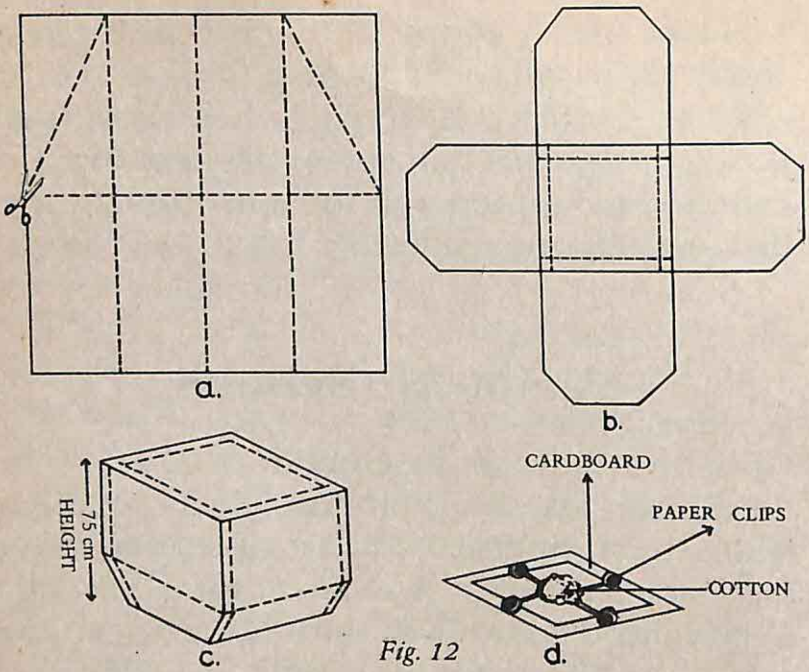

Fig. 12

old newspaper and fix the bases of the four sheets (mentioned earlier) one by one on it by means of gum. Let the edges overlap, say, by about 1 cm as shown in Fig. 12b. The next step should be to paste together the sides of the sheets to form a bag as shown in Fig. 12c. This is the most tedious part of the whole project. Every care should be taken to see that every side has been properly pasted and is neat and trim. Excess of gum at one corner will make the balloon tumble over while rising in the air.

Now take the cardboard and cut it into a square frame that could fit in with the open end of the bag or balloon. The frame is made 2.5 cm thick. Then take the paperclips, unfold them and attach two crossings each other to the frame as shown in Fig. 12d. A small bundle of cotton is also attached to the cross-wire of the frame by means of thread. The entire frame with the cotton is then fixed to the open end of the bag by using gum. Let the entire bag dry for some time in the sun. The hot-air balloon is ready for the launch.

First of all, check that all the corners of the tissue paper have been pasted well. There should be no scope for any leak in the bag. If there is any leak, the balloon will not rise. Having checked the leakage, take the bag to open ground where buildings are quite far away. Then sprinkle spirit over the cotton and holding the bag errect light the cotton using a matchstick. The balloon will not rise suddenly as one may expect it to. Wait till the time an

Fig. 13

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upward pull is felt at the hand and then slowly release the balloon. It will begin to rise, to everyone's delight. Note that the balloon should not be launched on a windy day. It will not only be damaged but may also cause damage.

A Galvanometer

Galvanometer is an instrument for detecting electricity and in a modified form may be used to measure it. Here is a simple way of making one at home and watching its uses.

Materials needed: A circular box (like a small cardboard powder box), a wooden bench, a long thin copper wire, nails, magnet, a thin strip of metal, wood and a thin sheet of paper.

The powder box, which is open at one side, is fixed centrally over the square wooden bench.

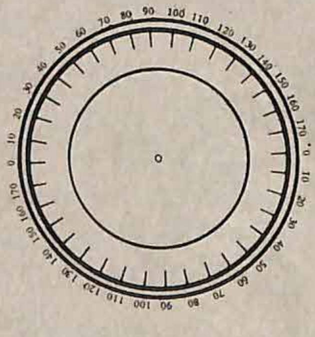


Fig. 14. Circular Scale. This should be of the same size as the inside of the box you choose. The divisions shown in the diagram can again be sub-divided into ten equal parts.

Make a circular scale of the inner size of the box as shown in Fig. 14. Paste it centrally on the base of the box. Fix a nail carefully from downside, so that its pointed end juts out from the centre of the scale.

Take the thin metal strip. Cut it out as shown in Fig. 15 in the shape of a needle. Magnetise it with the help of a magnet. This is done by rubbing the same pole of the magnet on the same side of the needle as shown in Fig. 15. When the strip begins attracting small items of metal, your needle is ready for use.

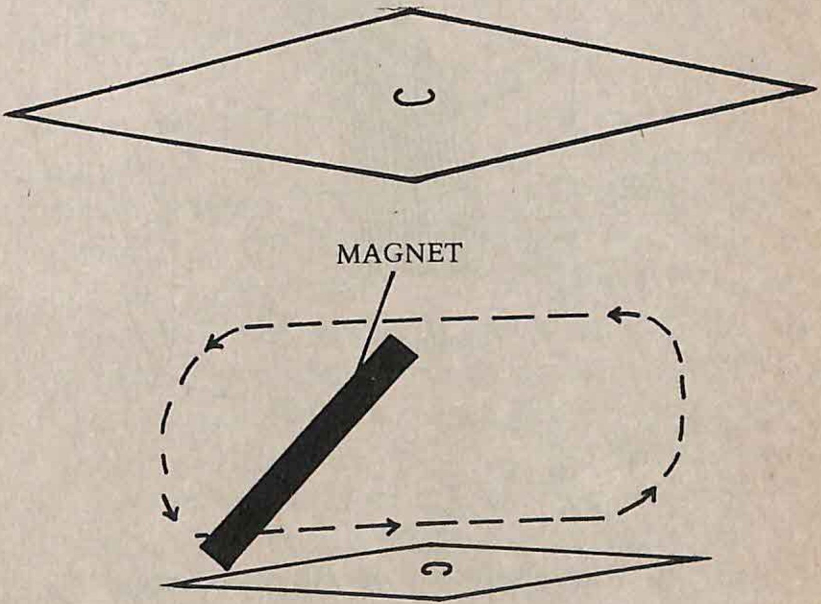


Fig. 15. Metal strip cut in the shape of a needle. In the centre is the sharply scratched point for resting the needle on a nail end (Top). (Bottom) Magnetising the metal strip: The metal strip can be magnetised by rubbing the same pole of the magnet on the same side of the needle. Soon the strip will begin attracting other metallic items.

Cut out small grooves at the edge of the powder box where the scale reads 0°—0° and wind the wire uniformly as shown in Fig. 16 and take out its terminals as shown. Place the needle over the pointed end of the nail. Care should be taken to ensure that the needle does not touch the wires and it moves freely. Your galvanometer is ready to serve you.

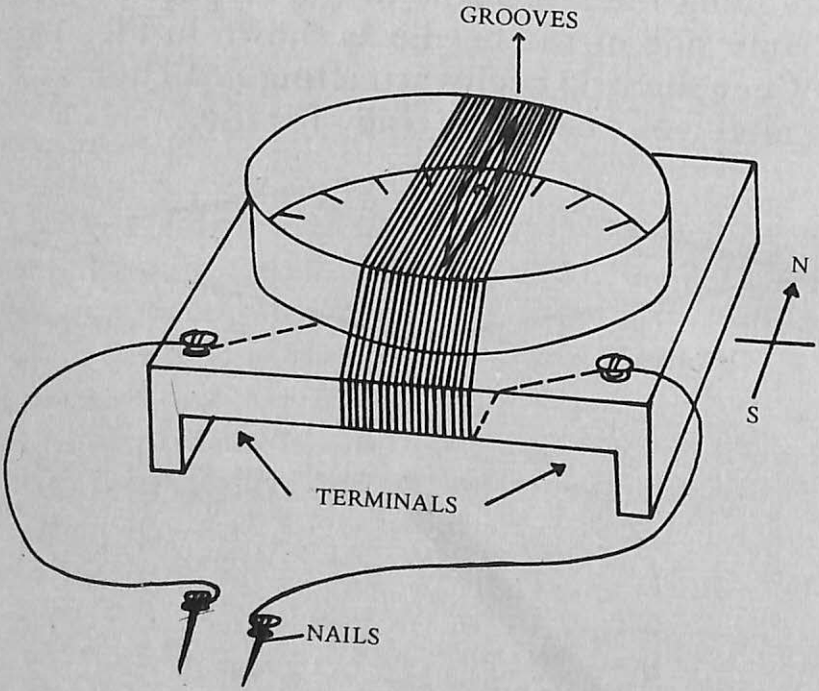


Fig. 16. Your galvanometer is now ready for experiments.

Setting the galvanometer is important for getting correct results. Let the needle come to rest. Then rotate the whole apparatus, so that the needle reads 0° — 0° in the above position. Now you can detect as well as measure current by it. Connect the terminals to the source, note the deflections at the two ends and record them.

You can put to use your galvanometer for many purposes. Here are some of them:

Old and new cells: Note the deflections when a torch cell is new and also after it has been used for some time. By noting deflections, you can find out whether a newly-bought cell is really new or a used one, and can also 'predict' a failure by testing it once a week or so. It is better to make the recordings in a table and see the gradual decrease in deflections.

Testing "lemon" current: Take a fresh lemon and press it slightly here and there, so that some of its tissues break. Then take a paperclip and straighten it up in the form of a wire. Using the paperclip make two holes in the lemon. Now connect the paperclip to one terminal of the galvanometer and insert the clip into one of the holes in the lemon. Take a thick copper wire and clean it with sandpaper. Connect this copper wire to the other terminal of the galvanometer. The free end of the copper wire should then be inserted in the other hole marked in the lemon. Care should be taken to see that the ends of the copper wire and the paperclip should be close to each other but should not touch each other (see Fig. 17).

As soon as the copper wire is inserted, the needle of the galvanometer will show a deflection, which, in other words, means that the

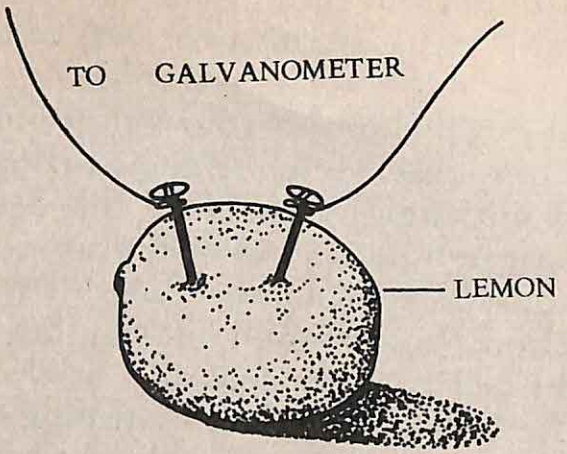


Fig. 17

lemon is generating a weak current of electricity. Instead of lemon, other fruits such as apple, orange, etc, may also be tested for a current. In each case note the deflection of the needle. From the degree of deflection the acid content of the fruit can be judged. The greater the deflection, the more is the acid present in it.

A Telegraph Set

Telegraph is a device for sending messages over a distance by means of wires. Here is one of the simplest ways of making a telegraph set at home.

Materials needed: Two metal rods, two short metal strips (stove pins), two long metal strips (the upper strip of an old calendar), nails of different sizes, a long copper wire, some ordinary wires, two pins, thin paper tape, two wooden boards, four wooden cylinders having a hole in the centre (the wooden reel of sewing thread), sandpaper and at least three torch cells.

Take the metal rod, clean it all around with the sandpaper and wind the thin copper wire over it uniformly. Take the two ends out. Cover it up with cellotape all over the wire, so that it may not get loose after some time. Fix the two ends on the board by nails. This system is called an electromagnet. Fix the electromagnet on the wooden board at a suitable place by cellotape.

Take the long metal strip, cut it and fold it in the form as shown in Fig. 18. At one end, fix a sharp needle or pin. Fix the whole strip on the board by small nails. Care should be taken to see that the metal strip is facing the electromagnet.

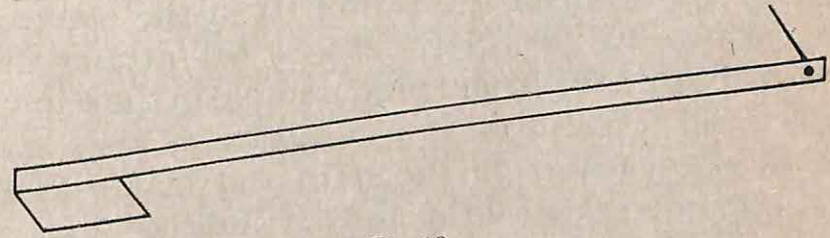


Fig. 18

Take another small strip of metal and fix it on the board with a nail at one end. Under the other end of the strip, fix another nail. These two are the terminals. This arrangement is called a 'tapping key'.

Make a roll of the paper tape of the width of the cylinder and wind it over one cylinder firmly. Fix the cylinder or reel on the board at a suitable place by passing a nail through its hole as shown in Fig. 19. Ensure that the cylinder rotates freely. Fix the other end of the paper, roll over the second reel and fit this also near the first one in the same way. Fix up a handle as shown in Fig. 19. Fix up two nails close to each other, so that the paper moves smoothly over them as shown.

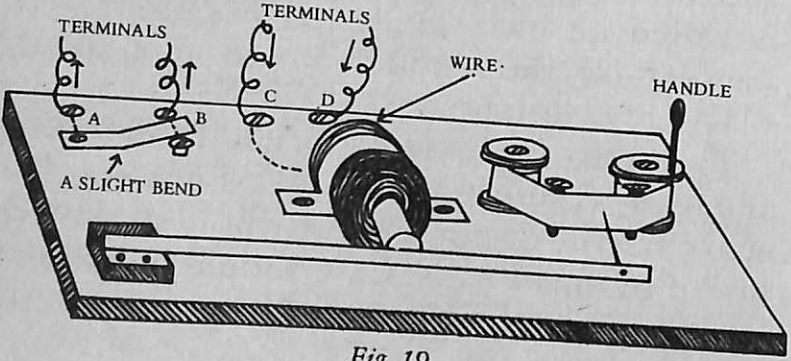


Fig. 19

Now connect the terminals of the electromagnet to the torch cells. It will attract the strip and the pin will pierce a hole in the paper. If this condition is not satisfied, take the magnet nearer to the strip and make other adjustments until the above condition is satisfied. Then fix up the electromagnet permanently by a metal strip. Now remove the connections. Make a similar arrangement. Keep them at a distance and connect them by ordinary wires as shown in Fig. 20. Your telegraph set is now ready for use.

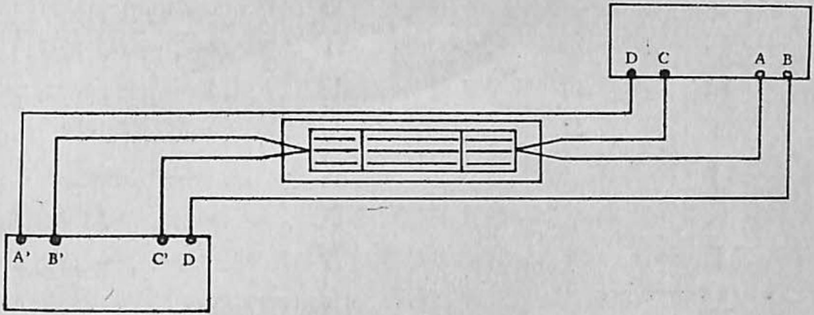


Fig. 20

Press the tapping key at one end and slowly rotate the cylinder at the other end. For this you must have a friend to operate on one set. When you press the tapping key for a moment, you will get a dot (pin hole) on the paper roll and, if pressed for a short while, you will get a dash (a slit). So, by using these dots and dashes, you can convey your message to the other end. An alphabet code is given separately, and you can have your own code for numbers like 1, 2, 3. Tabulate them on a sheet. Make a duplicate copy, and keep one with each telegraph set. Once you memorise these, you will find it very easy to send a message.

ALPHABET CODE

Alphabet	Code	Alphabet	Code
A	.	N	.—.—
B	. .	O	. . . —
C	. . .	P	—. . .
D	. . . .	Q	. .—.
E	.—	R	.—. . .

F	—.	S	—..—
G	—.—	T	.—.—..
H	.—.	U	..—.—.
I	..—	V	.—..—.
J	—..	W	..—..—
K	—..—	X	.—..—..
L	.— —.	Y	..—..—..
M	—.—.	Z	.—...—.

Can you read out the following message by using the code?

... ...— —.—. .— .—. .— .—....—

It is—COME HERE.

Finding the True North

If anybody were to ask you, "Which is the true north?" I am sure you will unhesitatingly advise him to take the help of a magnet. To a certain extent you are not wrong. However, it will not give you the true north! This is due to the fact that the earth's magnetic meridian (the imaginary line drawn all round the earth, passing through its magnetic north and south poles) is inclined at an angle of 11° to the true geographic meridian (the imaginary line drawn all round the earth passing through its geographic north and south poles). Therefore, the earth's magnetic north pole is near to the earth's geographic north pole. Thus using a magnet, you get the magnetic north and not the true north. There are many methods to find the true north. Here we shall do a simple experiment to find the true north by the help of the Sun.

Choose a clear day for your observations. Let there be no clouds in the sky. Place a table at such a place so that no shadow is cast by any surrounding objects during any time between 8.30 a.m. and 3.30 p.m. This observation should be taken the previous day.

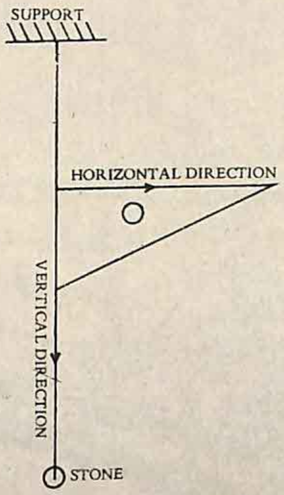


Fig. 21. Showing the use of plumb line and set square.

Place a wooden board on the table in a perfectly horizontal position. This should be tested using plumb line and set square, as shown in Fig. 21. Fix a sheet of paper on the board using drawing pins. Take a card paper and make a pin hole in it. Mount it at a higher level at one side of the table (as in Fig. 22) with the help of books or a wooden block and a weight, placing it roughly in the north-south direction. An oval shape image of the Sun will be formed over the sheet due to the pin-hole. Now the rest of the experiment is to mark out accurately the positions of this oval shape image at the given time. So select the accurate time—keeping watch of your house for your purpose. Mark the positions of the image at 9, 9.15 and 9.30 in the morning; a similar set of marks should be taken at 2.30, 2.45, and 3 in the afternoon.

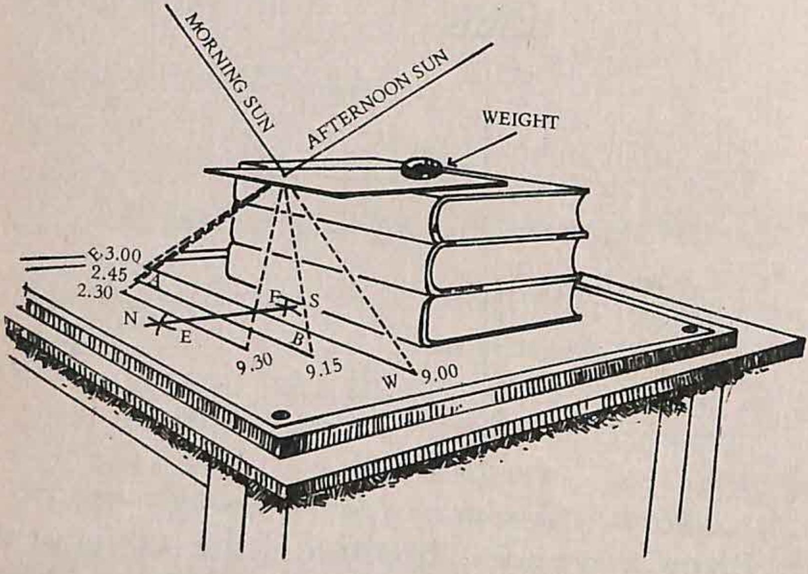


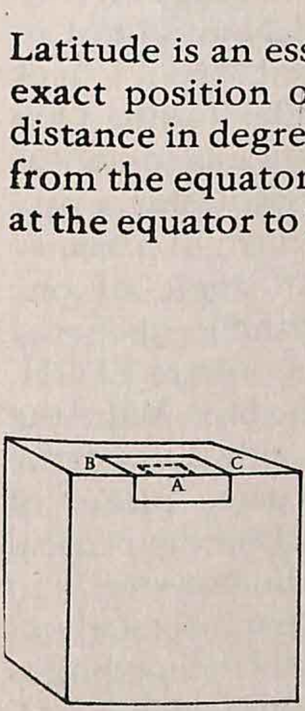
Fig. 22

Without disturbing the other things, take out the pin hole and its mounting arrangement. Join the mark made at 9 a.m. to that of 3 p.m., 9.15 a.m. to 2.45 p.m. and 9.30 a.m. to 2.30 p.m. These three lines show the direction of east-west. Now we have to draw a perpendicular to these lines. So, select two points A and

B on one of these three lines (Fig. 22). Take a compass and draw arcs of the same radius with A and B as centres. The arcs cut each other at E and F. Join EF. This gives you the true north-south direction. Draw perpendiculars to other lines and if you find all of them parallel to each other, you have done your experiment well. Now get the north-south direction using a magnet and you can see how far these two directions differ.

Finding the Latitude

Latitude is an essential measure for fixing the exact position of a place on earth. It is the distance in degrees of the place north or south from the equator. The distance ranges from 0° at the equator to 90° at the poles. If the place is



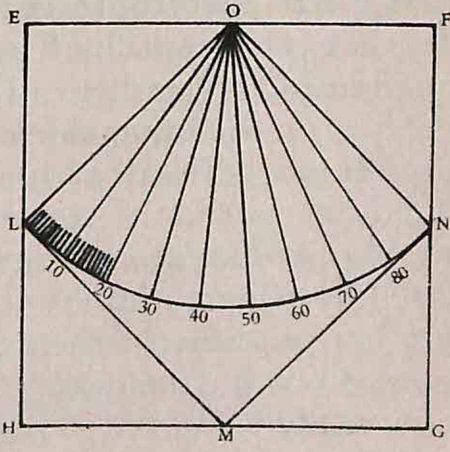


Fig. 23. Each of the nine parts of the quadrant is further divided into ten equal parts (Right).

in the northern hemisphere, its latitude is taken as positive, or negative if the place is in the southern hemisphere. There are many methods of getting the latitude of a place. Here we determine it taking the help of the sun.

Before trying the experiment, we have to construct a latitude box. Take a square cardboard box. Cut a square hole A at the centre of one of the sides (Fig. 23). Paste a small card paper over the hole shown by the outline between B and C. Draw a square EFGH on a piece of paper of the inside size of the box (Fig. 24). Find the mid points L,M,N and O of its sides and complete the square LMNO. Check that angle LON is a right-angle. Taking O as centre and ON or OL as the radius, draw the quadrant OLN using a compass. Using a protractor, divide this quadrant into 90 parts, so that each part represents an angle of one degree at O. Now rub off everything except the quadrant OLN and cut off the square EFGH. Paste it on the inner side of the box. Make the box stand vertical with the side OL of the quadrant perfectly vertical, using pieces of wood or some other support. Test the vertical line OL using a plumbline. The last step is to prick a pin-hole in the card paper exactly at point O of the quadrant. Your latitude box is now ready to do the experiment (see Fig. 24).

Select a window facing south for your observations. On a sunny day, shortly before

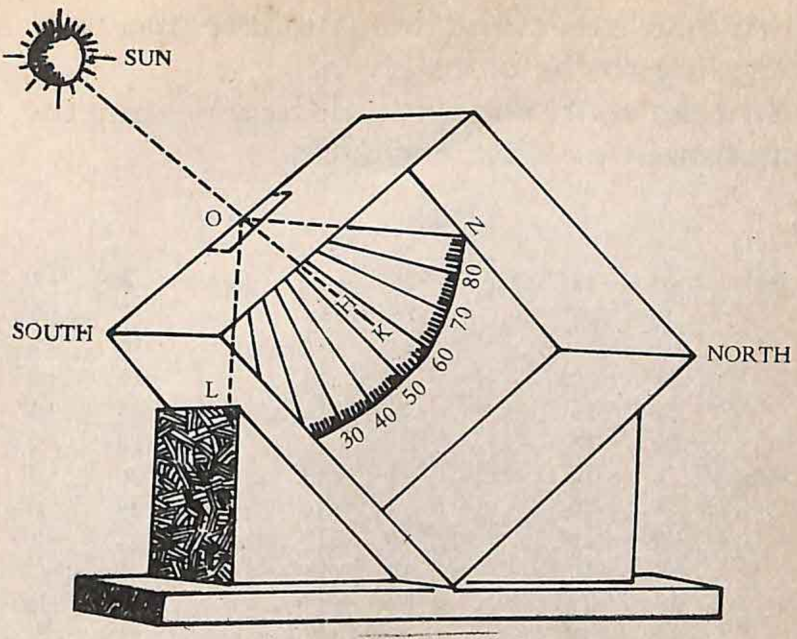


Fig. 24. The latitude box.

noon, place the latitude box with its plane containing the quadrant exactly in a north-south direction (found out in your previous experiment). The sunlight passing through the pin-hole will make a long, narrow image of the sun at H. As the sun approaches nearer and nearer to its highest point at noon, the sun's image will lengthen towards K and become narrower.

Just at noon the sun's image will be a narrow streak extending from the pin-hole to the graduated reading. At this moment, read out the exact number of degree and fractions as accurately as you can.

Now, to get the exact latitude, you add or subtract (according to the sign) the values given below from the one you have observed, according to the dates given.

You can verify your latitude by repeating the experiment on different dates.

TABLE

Jan.	1	−23°	Apr.	16	+10°	Sep.	4	+7°
	9	−22°		18	+11°		7	+6°
	16	−21°		21	+12°		10	+5°
	20	−20°		24	+13°		12	+4°
	25	−19°		28	+14°		15	+3°
	29	−18°					18	+2°
Feb.	1	−17°	May	1	+15°		20	+1°
	5	−16°		4	+16°		23	0°
	8	−15°		8	+17°		25	−1°
	11	−14°		11	+18°		28	−2°
	14	−13°		16	+19°		30	−3°
	17	−12°		20	+20°			
	20	−11°		25	+21°	Oct.	3	−4°
	22	−10°	Jun.	1	+22°		6	−5°
	25	−9°		10	+23°			−6°
	28	−8°		21	+23½°		11	−7°
Mar.	2	−7°	Jul.	3	+23°		14	−8°
	5	−6°		12	+22°		16	−9°
	8	−5°		18	+21°		19	−10°
	10	−4°		23	+20°		22	−11°
	13	−3°		28	+19°		25	−12°
	15	−2°					28	−13°
	18	−1°	Aug.	1	+18°		31	−14°
	20	0°		5	+17°	Nov.	3	−15°
	28	+1°		8	+16°		6	−16°
	25	+2°		12	+15°		9	−17°
	28	+3°		15	+14°		13	−18°
	31	+4°		18	+13°		17	−19°
Apr.	2	+5°		21	+12°		21	−20°
	5	+6°		24	+11°		26	−21°
	7	+7°		27	+10°	Dec.	2	−22°
	10	+8°		30	+9°		11	−23°
	13	+9°	Sep.	2	+8°		22	−23½°

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